

1. (previously presented)

A compact, energy-recycling homogenizer module for use in an illumination system

characterized by:

- a) folded optical channel means having at least one entry position and an exit position;
- b) entry port means at said folded optical channel entry position;
- c) a plurality of parallel, internally-reflective longitudinal surfaces in said folded optical channel;
- d) a plurality of internally-reflective latitudinal surfaces in said folded optical channel, perpendicular to said longitudinal surfaces; and
- e) exit port means at said folded optical channel exit position;

whereby such folded optical channel provides a complex multi-reflection uniformizing effect as most rays of a bundle of light rays in an entering beam travel with multiple complex internal reflections from entry means to exit means, and some light rays that are reflected back toward said entry port means are re-reflected in the forward direction and returned for recycling.

2. (previously presented)

A compact, energy-recycling homogenizer module for use in an illumination system

characterized by:

- a) folded optical channel means having a single entry position and a single exit position;
- b) entry port means at said folded optical channel entry position;
- c) a plurality of parallel, internally-reflective longitudinal surfaces in said folded optical channel;
- d) a plurality of internally-reflective latitudinal surfaces in said folded optical channel, perpendicular to said longitudinal surfaces; and
- e) exit port means at said folded optical channel exit;

whereby such folded optical channel provides a complex multi-reflection uniformizing effect as most rays of a bundle of light rays in an entering beam travel with multiple complex reflections from entry means to exit means, and some light rays that are reflected back toward said entry port means are reflected in the forward direction and returned for recycling.

12. (previously presented)

A compact, energy-recycling homogenizer module according to

Claim 1,

further characterized in that:

said optical channels are hollow and said internally-reflecting surfaces are mirrored surfaces.

13. (previously presented)

A compact, energy-recycling homogenizer module according to

Claim 1,

further characterized in that:

said optical channels are solid, made of a bulk optical material, and internal reflections in such solid channels take place by the phenomenon of total internal reflection.

14. (previously presented)

A compact, energy-recycling homogenizer module according to

Claim 1,

further characterized in that:

said optical channels are solid, made of a bulk optical material with mirrored internally-reflecting surfaces causing such internal reflections.

17. (previously presented)

A compact, energy-recycling homogenizer module according to
Claim 12,

further characterized in that:

said homogenizer is hollow, comprising:

a box enclosure set of two single-face mirror base members and two single-face mirror strips, each mirrored on one side only; forming an internally-mirrored box with open entry end and exit end;

a single-face mirror strip having an entrance aperture as entry port, closing the entry end of said box enclosure set, with entry port near a first corner;

10 a single-face mirror strip for use as a returning mirror opposite such entry port;

a set of two dual-face mirror strips, mirrored on both sides, that are shorter than said single-face mirror strips, mounted within said box enclosure set so as to define an internally-mirrored, folded channel having an optical axis with two returns, from said first corner to a diagonally-opposite third corner; and transparent exit port means near said third corner.

18. (previously presented)

A compact, energy-recycling homogenizer module according to

Claim 17,

further characterized in that:

said dual-face mirror strips overlap in the placement parallel to said optical axis.

19. (previously presented)

A compact, energy-recycling homogenizer module according to

Claim 13,

further characterized in that:

10 said bulk optical material is configured into separate optical channels constructed by providing slots in said solid optical material such that resulting slot surfaces are substantially smooth to provide total internal reflection in the bulk channels.

20. (previously presented)

A compact, high-efficiency, energy-recycling illumination system according to Claim 14,

further characterized in that:

said bulk optical material is configured into separate optical channels constructed by providing slots in said solid optical material such that resulting slot surfaces are substantially smooth and mirrorized to provide internal reflection in the bulk channels.

21. (withdrawn)

22. (previously presented)

A compact, energy-recycling homogenizer module according to
Claim 13,

further characterized in that:

said exit port is coated with an anti-reflective coating to minimize
reflections.

23. (previously presented)

A compact, energy-recycling homogenizer module according to
Claim 14,

10 further characterized in that:

said exit port is coated with a multilayer anti-reflective coating to
minimize reflections.

24. (previously presented)

A compact, energy-recycling homogenizer module according to
Claim 2,

further characterized by:

a conical indentation in the region of the returning face of said
homogenizer where central rays of the input beam are incident, so that such
central rays are reflected at a specified angle from the optical axis.

25. (Withdrawn)

26. (previously presented)

A compact homogenizer module for use in an illumination system according to Claim 1

further characterized in that:

the cross-sectional shape of each of said optical channels is a square.

27. (previously presented)

A compact homogenizer module for use in an illumination system according to Claim 1

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further characterized in that:

the cross-sectional shape of each of said optical channels is a rectangle.

28. (previously presented)

A compact homogenizer module for use in an illumination system according to Claim 1

further characterized in that:

the cross-sectional shape of each of said optical channels is a hexagon.

29. (previously presented)

A compact homogenizer module for use in an illumination system according to Claim 1

further characterized in that:

the cross-sectional shape of each of said optical channels is a circle.

30. (previously presented)

A compact homogenizer module for use in an illumination system according to Claim 1

further characterized in that:

10 the cross-sectional shape of each of said optical channels is a triangle.

31. (previously presented)

A compact homogenizer module for use in an illumination system according to Claim 1

further characterized in that:

the cross-sectional shape of at least one of said optical channels is different from the cross-sectional shape of another channel.

32. (previously presented)

A compact homogenizer module for use in an illumination system according to Claim 1

further characterized in that:

the cross-sectional shape of the first one of said optical channels is circular and the cross-sectional shape of the last channel is rectangular.

33. (previously presented)

A compact homogenizer module for use in an illumination system according to Claim 1

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further characterized in that:

the cross-sectional shape of the first one of said optical channels is circular and the cross-sectional shape of the last channel is hexagonal.

34. (previously presented)

A compact homogenizer module for use in an illumination system according to Claim 1

further characterized in that:

the cross-sectional shape of the first one of said optical channels is rectangular and the cross-sectional shape of the last channel is hexagonal.

35-37. (Withdrawn)

38. (previously presented)

A compact homogenizer module for use in an illumination system according to Claim 1,

further characterized in that:

the optical axes of the various channels form a bundle.

39-51. (Withdrawn)

52. (previously presented)

A compact, high-efficiency, energy-recycling according to Claim 17,

further characterized in that:

all mirrored surfaces are mirrorized by application of a reflective metal coating.

53. (previously presented)

A compact, high-efficiency, energy-recycling illumination system

according to Claim 17,

further characterized in that:

all mirrored surfaces are mirrorized by application of a reflective multilayer 10 dielectric coating.

54. (previously presented)

A compact, high-efficiency, energy-recycling illumination system

according to Claim 14,

further characterized in that:

said mirrored surfaces are made reflective by application of a reflective metal coating.

55. (previously presented)

A compact, high-efficiency, energy-recycling illumination system

according to Claim 14,

further characterized in that:

said mirrored surfaces are made reflective by application of a reflective multilayer dielectric coating.

56. (previously presented)

A compact energy-recycling homogenizer module for use in an illumination system according to Claim 1

further characterized in that:

10 internally-reflecting surfaces of input face and output face are

perpendicular to the optical axes of said optical channels; and

internally-reflecting walls of the optical channels are parallel to the optical axes of the channels.

57. (canceled)

58. (currently amended) A method of making a compact, energy-recyclng homogenizer for use in an illumination system, according to ~~Claim 57~~ the following steps:

Step 1) Arranging a first set of internally-reflective optical channel segments starting with an entry port and reflecting from an entry-channel reflective stop for return-forwarding a complex light beam bundle into a subsequent set of internally-reflective optical channel segments;

Step 2) Arranging the subsequent set of internally-reflecting optical channel segments to forward such complex light beam bundle, now more complex, in a generally reverse direction from said entry-channel reflective stop to reflect from a subsequent-channel reflective stop, which forwards an even more complex light beam bundle; and

Step 3) Arranging a final set of internally-reflecting optical channel segments to receive such even more complex light beam bundle, now having been homogenized to maximum complexity as it transits such final optical channel in a generally forward direction from said subsequent-channel reflective stop as a homogenized light beam bundle at an exit port ~~E~~ ¹⁷ further characterized in that:

there is a single-channel path leading from entry port to exit port with reflective stops for reversals at ends of entry-channel and all subsequent-channels except final channel.

59-61. (Withdrawn)

62. (previously presented)

An assembled-box method of making a compact, energy-recycling homogenizer for use in an illumination system, according to Claim 57,

further characterized in the following:

providing homogenizer body having at least one segmented optical channel with a pair of parallel internally-reflective exterior wall plates, a pair of perpendicular internally-reflective ends and a set of doubly-reflective internally-reflective short plates, defining the zigzag channel in a homogenizing complex optical path from each input port to exit port, with the result that a light beam entering said input port travels a complex plural-returning reflective path to said 10 output port.

63. (previously presented)

An assembled-box method of making a compact, energy-recycling homogenizer according to Claim 62, further characterized in that a single entry port is provided, leading into a complex plural-returning reflective path to a single output port.

64. (Withdrawn)

65. (previously presented)

An assembled-box method of making a compact, energy-recycling homogenizer according to Claim 62, further characterized in that reflective
10 metallization is used to form internal mirrors.

66. (previously presented)

An assembled-box method of making a compact, energy-recycling homogenizer according to Claim 62, further characterized in that multilayer dielectric coatings are used to form internal mirrors.

67. (previously presented)

A slotted-block method of making a compact, energy-recycling homogenizer according to Claim 57, further characterized by:

providing a solid block of an optical material;

providing slots in said solid block to delineate a complex set of optical channel segments operable for homogenization of entering light.

68. (previously presented)

A slotted-block method of making a compact, energy-recycling homogenizer according to Claim 67, further characterized in that:

10 there are two short slots, parallel to the axes of the optical channels and positioned at opposite ends of the block, provided with reflective means so as to define a complex, homogenizing segmented optical channel from a single entry port to a single exit port.

69-70. (Withdrawn)

71. (previously presented)

A slotted-block method of making a compact, energy-recycling homogenizer according to Claim 67, further characterized in that said slots are mirrorized after fabrication.

72. (previously presented)

A slotted-block method of making a compact, energy-recycling homogenizer according to Claim 71, further characterized in that said slots are made capable of total internal reflection after fabrication, by at least one of chemical polishing, mechanical polishing, and chemical/mechanical polishing.

73. (previously presented)

A slotted-block method of making a compact, energy-recycling homogenizer according to Claim 71, further characterized in that said slots are mirrorized, after fabrication, by forming a reflective metallic coating on the inside surfaces of each slot.

74-78. (Withdrawn)

79. (previously presented) A compact, high-efficiency, energy-recycling homogenizer module appropriately juxtaposable to accept radiation in a first format and to reformat such radiation to a processed format for optical projection

characterized by:

- a) entry means, to accept radiation into such homogenizer;
- b) labyrinth means, optically subsequent to said entry means, having a plurality of internally-reflective longitudinally directing principally forwarding surfaces and having also a plurality of latitudinal directing principally returning surfaces, for a complex multi-reflection directing and returning intensity uniformization and energy-recycling light path; and
- c) exit re-entry means, to forward radiation for partial utilization and partial return for recycling.

80. (previously presented) A compact, high-efficiency, energy-recycling illumination system according to Claim 79,

further characterized in that:

said labyrinth means maintains numeric aperture and produces self-luminous radiation at said exit re-entry means.

81. (previously presented) A compact, high-efficiency, energy-recycling illumination system according to Claim 80,

further characterized in that:

said labyrinth means provides a broad-spectrum self-luminous white light emission at said exit-re-entry means in response to a white light beam at said entry means, and recycles white light reflected back into said exit-re-entry means, processing such reflected light during such recycling so as to be self-luminous and with unchanged numeric aperture.

82. (previously presented) A compact, high-efficiency, energy-recycling illumination system according to Claim 80,

further characterized in that:

said labyrinth means provides a narrow-spectrum self-luminous ultra-violet emission at said exit-re-entry means in response to a narrow-spectrum ultraviolet beam at said entry means, and recycles ultraviolet radiation reflected back into said exit-re-entry means, processing such reflected radiation during such recycling so as to be self-luminous and with unchanged numeric aperture.